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DEVELOPMENT OF A MODULARIZED SIMULATOR OF A LOW EARTH ORBIT RADIO-OPTICAL HYBRID COMMUNICATION SATELLITE CONSTELLATION FOR SYSTEM-LEVEL DESIGN STUDIES

Abstract

The demand for better communication systems is increasing across various industries and sectors. In aviation and maritime industries, reliable in-flight and ship-to-shore communication is essential for passenger and crew satisfaction and operational efficiency. The healthcare industry requires low-latency communication systems for remote healthcare services. Disaster response teams need reliable communication networks in disaster-stricken areas. IoT industry needs higher coverage communication systems for real-time data analysis and response. Smart agriculture relies on communication systems for monitoring crop growth, soil quality, and weather conditions. Smart infrastructure, such as smart cities and buildings, can support smart traffic management, energy-efficient lighting, and public safety applications. Finally, connected cars and autonomous vehicles require real-time interaction with their surroundings to improve road safety and traffic flow.

A low earth orbit radio-optical hybrid communication satellite constellation has been proposed to

meet the aforementioned needs. However, designing such a system is challenging due to the constantly changing network topology and weather conditions that can interrupt communication. Uncertainty in the future communication demand can also affect the system deployment strategy and business feasibility.

This study presents a modularized simulator of a low earth orbit radio-optical hybrid communication satellite constellation to assist these system-level design studies. The simulator has four modules:

1. The Constellation Orbital Elements Calculator: Takes high-level parameters such as the Walker-Delta constellation's four parameters and outputs the orbital elements of each satellite.
2. The Communication Link Calculator: Takes the orbital elements of each satellite, the location of gateways and users, and the specifications of the communication equipment, and outputs the communication bandwidth profile between nodes in the communication network.
3. The Communication Demand Router: Takes the communication bandwidth profile and communication demand and outputs the routing result based on a predefined routing strategy.
4. The Stochastic System-Level Simulator: Simulates the data transmission with the routing result under the stochasticity of the weather condition and satellite failure to evaluate the system performance under uncertainty.

The simulator is modularized and thus flexible, enabling various system-level design studies including, but not limited to, constellation optimization, gateway location optimization, and robust routing strategy development. This study also presents the initial results from system-level design studies using the simulator.